TRANSFORMATIONS OF SOME 3-BENZAMIDO-2,5-DIOXO-5,6,7,8-TETRAHYDRO-2*H*-1-BENZOPYRANS WITH NUCLEOPHILES

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Abstract - Transformation of 3-benzamido-2,5-dioxo-5,6,7,8-tetrahydro-2*H*-1-benzopyrans (**1-3**) to the corresponding quinolin-2(1*H*)-ones (**4-18**) with nitrogen-containing nucleophiles (amines and hydrazines) under various conditions is described. In order to clarify the observed results, heats of formation of possible product pairs were calculated.

Recent progress in the field of 2*H*-1-benzopyran-2-ones has shown the importance of this class of compounds for synthetic purposes[1,2] and for their use as biologically active compounds.[3] Among them, 5,6,7,8-tetrahydro-2*H*-1-benzopyran-2,5-diones have not yet been completely investigated. It has been shown that they can be transformed to the quinoline system by the action of nitrogen-containing nucleophiles.[2] In some cases two nitrogen atoms were incorporated into such type of molecule.[2c-e] Various 5-amino-5,6,7,8-tetrahydroquinolines were synthesized as acetylcholinesterase inhibitors.[2h] Some substituted 2*H*-1-benzopyran-2-ones and quinolinones are known inhibitors of DNA topoisomerases,[3c] therefore, studies with various drug - DNA binding models could open up new possibilities for the designing of new drugs which might be used as antibacterial compounds.[4] For this reason, selective transformations of the benzopyran-2-1*H*-one system into the appropriate quinolinones or substituted benzopyranones would be of importance. 5,6,7,8-Tetrahydro-2*H*-1-benzopyran-2,5-diones could, at least theoretically, react with a nitrogen-containing nucleophile at either the 5-oxo group to yield an imino- or hydrazonobenzopyran or at the pyranone ring to form a quinoline system.

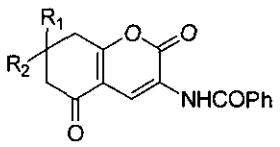
As a continuation of our work in the field of transformations of 5,6,7,8-tetrahydro-2*H*-1-benzopyran-2,5-diones with nitrogen-containing nucleophiles,[2f,g] we investigated the possibility of

reactions at both positions: with the lactone ring and with the oxo group on the condensed ring. We selected reagents, in which an amino group contains substituents causing various stereoelectronic effects, and studied their reactivity as nucleophiles towards 5,6,7,8-tetrahydro-2*H*-1-benzopyran-2,5-diones (**1-3**).[5] We performed reactions of compounds (**1-3**) with *N,N*-dimethylhydrazine, aniline, D,L-alanine, glycylglycine and hydrazine. Reactions with *N,N*-dimethylhydrazine were carried out in dry ethanol under the influence of *p*-toluenesulfonic acid as a catalyst. Acids have proven to catalyze conversions of various carbonyls with the amino derivatives.[2h,6] In these reactions we used a five-times excess of *N,N*-dimethylhydrazine. In all cases we isolated quinolinones (**4-6**) as the only products in 70-81% yield. In transformations of benzopyrans (**1-3**) with aniline (in the molar ratio 1:5) in ethanolic solution with *p*-toluenesulfonic acid as a catalyst, after 10 h of heating, tlc has shown the formation of several products plus the starting compound. For this reason, the reactions were carried out with an excess (5 equivalents) of boiling aniline and without a catalyst. Isolated yields of the corresponding quinolinones (**7-9**) were in these particular cases, between 56 and 67% but no 5-imino derivatives were obtained. Reactions of benzopyrans (**1-3**) with D,L-alanine or glycylglycine were performed under the alkaline conditions in boiling *N,N*-dimethylformamide, with an excess (4- or 2-times) of the amino reagent, yielding quinolinone derivatives (**10-15**) in various yields. It has been shown recently, that compound **3** reacts with hydrazine hydrate to give the corresponding 1-amino derivative.[2f] For this reason we tried the reaction under more drastic conditions - on heating in an excess of hydrazine hydrate. The reaction took place at the pyranone ring and at the 5-oxo group, and even debenzoylation of the benzoylamino group occurred, yielding 5-hydrazonoquinolinones (**16-18**).

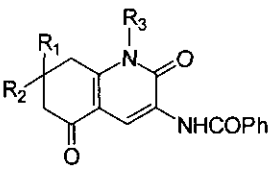
Calculated heats of formation obtained at the semiempirical Hartree-Fock level[7,8] of computation show that quinolinone derivatives represent more stable isomers in comparison with the corresponding fictitious 5-hydrazonobenzopyran isomers (**19**). Heats of formation for compounds (**4-9**) as well as for 1-amino derivatives were calculated. Differences (0.7-7.0 kcal/mol) between the heats of formation for the compound pairs consistently matched the experimental findings (see results in experimental).

One could generalize, as shown from our results and also from already known observations,[2] that the reaction of 3-substituted 5,6,7,8-tetrahydro-2*H*-1-benzopyran-2,5-diones with amines, including ammonia and hydroxylamine, and with hydrazines bearing alkyl substituents, takes place in the lactone ring.

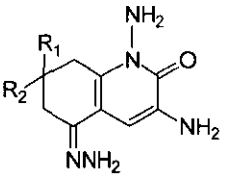
Scheme



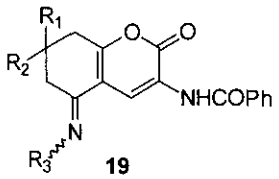
	R_1	R_2
1	H	H
2	H	Me
3	Me	Me



	R_1	R_2	R_3
4	H	H	NMe_2
5	H	Me	NMe_2
6	Me	Me	NMe_2
7	H	H	Ph
8	H	Me	Ph
9	Me	Me	Ph
10	H	H	$CH(Me)CO_2H$
11	H	Me	$CH(Me)CO_2H$
12	Me	Me	$CH(Me)CO_2H$
13	H	H	$CH_2CONHCH_2CO_2H$
14	H	Me	$CH_2CONHCH_2CO_2H$
15	Me	Me	$CH_2CONHCH_2CO_2H$



	R_1	R_2
16	H	H
17	H	Me
18	Me	Me



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EXPERIMENTAL

Melting points were determined on a Kofler micro hot stage and are uncorrected. Nmr spectra were recorded on a Varian EM360L, JEOL JNM FX90Q and Bruker Avance DPX 300 *spectrometers in DMSO-d_6 (if not stated differently)*, using TMS as an internal standard. Ir spectra were obtained with a Perkin Elmer 1310 spectrophotometer, using KBr pellets. Mass spectra were obtained with a VG-Analytical AutospecQ instrument. Elemental analysis (C, H, N) were performed with a Perkin Elmer 2400 CHN Analyzer: Tlc was carried out on FLUKA silica gel plates (F_{254}). Compounds (**1-3**)[5] were prepared as described in the literature. All other compounds including *N,N*-dimethylhydrazine (99%) and hydrazine hydrate (99%) were used without purification as obtained from commercial sources (Merck, Aldrich, Fluka).

General procedure for the synthesis of compounds **(4-6)**. *p*-Toluenesulfonic acid (19 mg, 0.1 mmol) was added to the mixture of *N,N*-dimethylhydrazine (300 mg, 5 mmol) and the benzopyran (**1-3**) (1 mmol) in dry ethanol (5 ml). The reaction mixture was refluxed for 4 h (3.5 h in the case of **2**). Upon cooling, product was separated by filtration. Yields: 88% of **4**, 75% of **5**, 70% of **6**.

General procedure for the synthesis of compounds **(7-9)**. A mixture of aniline (465 mg, 5 mmol) and 1 mmol the benzopyran (**1-3**) was heated at 180 °C for 2.5 h. Upon cooling,

ethanol (3 ml) was added to the reaction mixture and the product was separated by filtration. Yields: 56% of **7**, 67% of **8**, 65% of **9**.

***General procedure for the synthesis of compounds* (10-15).** To a solution of sodium methoxide, prepared from 96 mg (4 mmol) of sodium and 8 ml of dry methanol, 365 mg (4 mmol) of D,L-alanine [or 528 mg (4 mmol) of glycylglycine] was added and the resulting solution was evaporated *in vacuo* to dryness. The residue was treated with 1 mmol (2 mmol in the case of glycylglycine) of the benzopyran (**1-3**) and 10 ml of *N,N*-dimethylformamide. The resulting reaction mixture was refluxed for 2 h (45 min in the case of glycylglycine) and then evaporated *in vacuo*. The remaining residue was suspended in 3.0 ml (2 ml) of water, the suspension was cooled and acidified with hydrochloric acid (18%) to *p*H 2-3. The separated product was filtered off and washed with a small amount of water. Yields: 38% of **10**, 52% of **11**, 18% of **12**, 51% of **13**, 77% of **14**, and 65% of **15**. Yields for compounds **10**, **11** and **12** correspond to crystallized products. (Products originated from D,L-alanine were isolated as mixtures of stereoisomers.)

***General procedure for the synthesis of compounds* (16-18).** A mixture of hydrazine hydrate (2 ml, 40.7 mmol) and 1 mmol the benzopyran (**1-3**) was heated at 110 °C for 3 h. Upon cooling, the separated solid was filtered off and washed with water. Yields: 91% of **16**, 63% of **17**, 76% of **18**.

***Analytical and spectroscopic data of compounds* 4-18:**

3-Benzamido-1-dimethylamino-2,5-dioxo-1,2,5,6,7,8-hexahydroquinoline (4): mp 199-201 °C (from MeOH); ^{1}H nmr (60 MHz) δ 2.04 (m, 2H, 7-CH_2), 2.48 (m, 2H, 6-CH_2), 3.10 (m, 2H, 8-CH_2), 3.02 (s, 6H, NMe_2), 7.62 (m, 3H, Ph), 8.01 (m, 2H, Ph), 8.66 (s, 1H, 4-H), 9.39 (br s, 1H, NH); ^{13}C nmr (75.5 MHz) δ 20.7, 25.2, 36.0, 42.5, 112.9, 119.6, 126.9, 127.2, 128.7, 132.0, 133.6, 155.0, 158.5, 164.9, 194.0; ir 1633 br, 1670 cm^{-1}; ms (m/z) 325 (M^+, 20%), 105 (100). Anal. Calcd for $C_{18}H_{19}N_3O_3$: C, 66.45; H, 5.89; N, 12.91. Found: C, 66.27; H, 6.04; N, 13.04.

3-Benzamido-1-dimethylamino-7-methyl-2,5-dioxo-1,2,5,6,7,8-hexahydroquinoline (5): mp 220-222 °C (MeOH); ^{1}H nmr (60 MHz) δ 1.10 (deg d, 3H, 7-Me), 2.00-2.90 (m, 5H, 7-H, 6-CH_2, 8-CH_2), 3.00 (s, 3H, Me), 3.02 (s, 3H, Me), 7.60 (m, 3H, Ph), 7.98 (m, 2H, Ph), 8.62 (s, 1H, 4-H), 9.36 (br s, 1H, NH); ^{13}C nmr (75.5 MHz) δ 20.8, 28.0, 33.0, 42.42, 42.46, 43.9, 112.5, 119.5, 126.9, 127.2, 128.6, 132.0, 133.6, 154.2, 158.6, 164.9, 194.0; ir 1632 br, 1668 cm^{-1}. Anal. Calcd for $C_{19}H_{21}N_3O_3$: C, 67.24; H, 6.24; N, 12.38. Found: C, 66.98; H, 6.29; N, 12.67.

3-Benzamido-1-dimethylamino-7,7-dimethyl-2,5-dioxo-1,2,5,6,7,8-hexahydroquinoline (6): mp

175-178 °C (MeOH); ^{1}H nmr (300 MHz) δ 1.08 (s, 6H, two Me), 2.42 (s, 2H, 6-CH_2), 3.03 (s, 2H, 8-CH_2), 3.00 (s, 6H, NMe_2), 7.57 (m, 3H, Ph), 7.95 (m, 2H, Ph), 8.60 (s, 1H, 4-H), 9.32 (br s, 1H, NH); ^{13}C nmr (75.5 MHz) δ 27.8, 31.9, 38.5, 42.5, 49.4, 112.0, 119.2, 126.9, 127.2, 128.7, 132.0, 133.6, 152.9, 158.7, 165.0, 193.9; ir 1632, 1675 cm^{-1}. Anal. Calcd for $C_{20}H_{23}N_3O_3$: C, 67.97; H, 6.56 N, 11.89. Found: C, 67.95; H, 6.57; N, 11.57.

3-Benzamido-2,5-dioxo-1-phenyl-1,2,5,6,7,8-hexahydroquinoline (7): mp 247-249 °C (DMF/MeOH); ^{1}H nmr (60 MHz) δ 1.92 (m, 2H, 7-CH_2), 2.30-2.60 (m, 4H, 6-CH_2, 8-CH_2), 7.58 (m, 8H, *N*-Ph, 3H of Ph), 7.98 (m, 2H, Ph), 8.81 (s, 1H, NH), 9.36 (br s, 1H, NH); ^{13}C nmr (75.5 MHz) δ 20.9, 27.9, 36.1, 113.4, 120.0, 126.4, 127.1, 127.9, 128.7, 129.2, 129.6, 132.0, 133.7, 137.2, 152.1, 158.4, 165.0, 194.0; ir 1632, 1668 cm^{-1}; ms (m/z) 358 (M^+, 56), 105 (100). Anal. Calcd for $C_{22}H_{18}N_2O_3$: C, 73.73; H, 5.06; N, 7.82. Found: C, 73.89; H, 5.18; N, 8.08.

3-Benzamido-7-methyl-2,5-dioxo-1-phenyl-1,2,5,6,7,8-hexahydroquinoline (8): mp 253-256 °C (DMF/MeOH); ^{1}H nmr (60 MHz) δ 0.94 (deg d, 3H, Me), 2.10-2.40 (m, 5H, 7-H, 6-CH_2, 8-CH_2), 7.60 (m, 8H, *N*-Ph, 3H of Ph), 8.00 (m, 2H, Ph), 8.81 (s, 1H, 4-H), 9.38 (br s, 1H, NH); ^{13}C nmr (75.5 MHz) δ 20.5, 28.3, 35.6, 44.0, 113.0, 119.8, 126.4, 127.1, 127.8, 128.1, 128.7, 129.2, 129.6, 129.7, 132.0, 133.6, 137.2, 151.3, 158.5, 165.0, 193.9 (21 signals as required); ir 1635, 1670 cm^{-1}; ms (m/z) 372 (M^+, 54), 105 (100). Anal. Calcd for $C_{23}H_{20}N_2O_3$: C, 74.18; H, 5.41; N, 7.52. Found: C, 73.79; H, 5.37; N, 7.54.

3-Benzamido-7,7-dimethyl-2,5-dioxo-1-phenyl-1,2,5,6,7,8-hexahydroquinoline (9): mp 253-256 °C (DMF/MeOH); ^{1}H nmr (60 MHz) δ 0.96 (s, 6H, two Me), 2.34 (s, 2H) and 2.40 (s, 2H) (6-CH_2, 8-CH_2), 7.58 (m, 8H, *N*-Ph, 3H of Ph), 7.98 (m, 2H, Ph), 8.80 (s, 1H, 4-H), 9.35 (br s, 1H, NH); ^{13}C nmr (75.5 MHz, $CDCl_3$) δ 28.2, 33.1, 41.9, 50.3, 114.3, 118.8, 127.1, 127.4, 127.6, 128.8, 129.7, 130.3, 132.1, 134.0, 137.2, 147.9, 159.5, 165.4, 193.7; ir 1634, 1670 cm^{-1}; ms (m/z) 386 (M^+, 73), 105 (100). Anal. Calcd for $C_{24}H_{22}N_2O_3$: C, 74.59; H, 5.74; N, 7.25. Found: C, 74.43; H, 5.77; N, 7.32.

2-[3-(Benzoylamino)-2,5-dioxo-1,2,5,6,7,8-hexahydro-1-quinolinyl]propanoic acid (10): mp 249-251 °C (EtOH); ^{1}H nmr (60 MHz) δ 1.58 (d, 3H, J = 7 Hz, CH_3CH), 1.90-4.10 (m, 6H, 6-CH_2, 7-CH_2, 8-CH_2), 5.30 (q, 1H, J = 7 Hz, CH_3CH), 7.63 (m, 3H, Ph), 8.02 (m, 2H, Ph), 8.83 (s, 1H, 4-H), 9.43 (br s, 1H, NH); ir 1630br, 1678, 1736 cm^{-1}; ms (m/z) 354 (M^+, 43), 105 (100). Anal. Calcd for $C_{19}H_{18}N_2O_5 \bullet 0.75H_2O$: C, 62.03; H, 5.34; N, 7.61. Found: C, 62.23; H, 5.28; N, 7.54.

2-[3-(Benzoylamino)-7-methyl-2,5-dioxo-1,2,5,6,7,8-hexahydro-1-quinolinyl]propanoic acid (11): mp 272-274 °C (EtOH); ^{1}H nmr (60 MHz) δ 1.04-1.32 (br, 3H, Me), 1.58 and 1.60 (two d,

3H, J = 7 Hz, CH_3CH), 2.18-3.60 (m, 5H, 7-H, 6-CH_2, 8-CH_2), 5.33 (m, 1H, CH_3CH), 7.65 (m, 3H, Ph), 8.07 (m, 2H, Ph), 8.81 (s, 1H, 4-H), 9.44 (br s, 1H, NH), 12.64-13.14 (br s, 1H, OH); ir 1632br, 1680, 1752 cm^{-1}. Anal. Calcd for $C_{20}H_{20}N_2O_5$: C, 65.21; H, 5.47; N, 7.60. Found: C, 65.43; H, 5.53; N, 7.42.

2-[3-(Benzoylamino)-7,7-dimethyl-2,5-dioxo-1,2,5,6,7,8-hexahydro-1-quinolinyl]propanoic acid (12): mp 260-263 °C (EtOH); ^1H nmr (90 MHz) δ 1.07 (s, 3H, Me), 1.11 (s, 3H, Me), 1.59 (d, 3H, J = 6.8 Hz, CH_3CH), 2.44 (deg dd, 2H) and 2.94 (deg dd, 2H), (6-CH_2, 8-CH_2), 5.33 (q, 1H, J = 6.8 Hz, CH_3CH), 7.57 (m, 3H, Ph), 7.91 (m, 2H, Ph), 8.69 (s, 1H, 4-H), 9.14 (br s, 1H, NH); ir 1630br, 1680, 1743 cm^{-1}. Anal. Calcd for $C_{21}H_{22}N_2O_5$: C, 65.96; H, 5.80; N, 7.33. Found: C, 65.90; H, 6.13; N, 7.01.

***N*-[[3-(Benzoylamino)-2,5-dioxo-1,2,5,6,7,8-hexahydro-1-quinolinyl]acetyl]glycine (13):** mp 247-250 °C (EtOH); ^1H nmr (60 MHz) δ 1.87-3.59 (m, 6H, 6-CH_2, 7-CH_2, 8-CH_2), 3.88 (d, 2H, J = 6 Hz, $NHCH_2$), 4.99 (s, 2H, NCH_2), 7.60 (m, 3H, Ph), 7.99 (m, 2H, Ph), 8.58-8.89 (m, 2H, $NHCH_2$, 4-H), 9.37 (br s, 1H, NH); ir 1625br, 1673, 1736 cm^{-1}. Anal. Calcd for $C_{20}H_{19}N_3O_6$: C, 60.45; H, 4.82; N, 10.57. Found: C, 60.25; H, 4.90; N, 10.52.

***N*-[[3-(Benzoylamino)-7-methyl-2,5-dioxo-1,2,5,6,7,8-hexahydro-1-quinolinyl]acetyl]glycine (14):** mp 240-242 °C (EtOH); ^1H nmr (60 MHz) δ 0.94-1.30 (deg d, 3H, Me), 2.15-3.07 (m, 5H, 7-H, 6-CH_2, 8-CH_2), 3.89 (d, 2H, J = 6 Hz, $NHCH_2$), 4.99 (s, 2H, NCH_2), 7.65 (m, 3H, Ph), 8.03 (m, 2H, Ph), 8.61-8.95 (m, 2H, $NHCH_2$, 4-H), 9.40 (br s, 1H, NH), 12.50 (br s, 1H, OH); ir 1635br, 1677, 1755 cm^{-1}. Anal. Calcd for $C_{21}H_{21}N_3O_6$: C, 61.31; H, 5.14; N, 10.21. Found: C, 60.96; H, 5.30; N, 10.14.

***N*-[[3-(Benzoylamino)-7,7-dimethyl-2,5-dioxo-1,2,5,6,7,8-hexahydro-1-quinolinyl]acetyl]glycine (15):** mp 143-145 °C (EtOH); ^1H nmr (90 MHz) δ 1.05 (s, 6H, two Me), 2.40 (s, 2H, 6-CH_2), 2.83 (s, 2H, 8-CH_2), 3.82 (d, 2H, J = 5.6 Hz, $NHCH_2$), 4.95 (s, 2H, NCH_2), 7.56 (m, 3H, Ph), 7.90 (m, 2H, Ph), 8.55 (t, 1H, J = 5.6 Hz, $NHCH_2$), 8.69 (s, 1H, 4-H), 9.23 (br s, 1H, NH); ir 1635br, 1690, 1740 cm^{-1}; FAB-ms (m/z) 426 (MH^+). Anal. Calcd for $C_{22}H_{23}N_3O_6 \bullet 0.5\ H_2O$: C, 60.82; H, 5.57; N, 9.67. Found: C, 60.54; H, 5.53; N, 9.61.

1,3-Diamino-5-hydrazono-2-oxo-1,2,5,6,7,8-hexahydroquinoline (16): mp 226-228 °C (DMF); ^1H nmr (60 MHz) δ 1.53-3.00 (m, 6H, 6-CH_2, 7-CH_2, 8-CH_2) 4.87 (s, 2H, NH_2), 5.93 (s, 4H, two NH_2), 7.10 (s, 1H, 4-H); 1595br, 1627, 1670 cm^{-1}. Anal. Calcd for $C_9H_{13}N_5O$: C, 52.16; H, 6.32; N, 33.79. Found: C, 52.05; H, 6.53; N, 33.49.

1,3-Diamino-5-hydrazono-7-methyl-2-oxo-1,2,5,6,7,8-hexahydroquinoline (17): mp 247-249 °C (DMF); ^1H nmr (90 MHz) δ 1.03-1.1 (d, 3H, J = 5.86 Hz, Me), 1.81-3.13 (m, 5H, 7-H, 6-CH_2,

8-CH_2) 4.87 (s, 2H, NH_2), 5.89 (s, 4H, two NH_2), 7.06 (s, 1H, 4-H); ir 1595br, 1615, 1645 cm^{-1}. Anal. Calcd for $C_{10}H_{15}N_5O$: C, 54.28; H, 6.83; N, 31.65. Found: C, 54.34; H, 7.13; N, 31.36.

1,3-Diamino-5-hydrazono-7,7-dimethyl-2-oxo-1,2,5,6,7,8-hexahydroquinoline (18): mp 250-253 °C (DMF); ^1H nmr (60 MHz) δ 0.99 (s, 6H, two Me), 2.18 (s, 2H) and 2.67 (s, 2H) (6-CH_2, 8-CH_2) 4.90 (s, 2H, NH_2), 5.92 (s, 2H, NH_2), 6.02 (s, 2H, NH_2), 7.13 (s, 1H, 4-H); ir 1580br cm^{-1}. Anal. Calcd for $C_{11}H_{17}N_5O$: C, 56.15; H, 7.28; N, 29.76. Found: C, 56.21; H, 7.52; N, 29.71.

Methods of Calculation. The geometries of all compounds studied were completely optimized at the semiempirical Hartree-Fock level using program package Spartan.[7] Standard AM1 parameters were used.[8] Starting structure was taken from the X-ray diffraction study of benzopyran derivative (**3**).[9] The conformational analysis was performed by first repetitive, exhaustive search for the lowest energy conformer around dihedral angles of the substituents in position 1 and 5, followed by optimization until the maximum gradient did not exceed $5 \bullet 10^{-3}$ kcal/mol.

Results. Calculated heats of formation Hf (kcal/mol): for **4** -14.5 (-11.7); **5** -18.2 (-15.5); **6** -21.3 (-18.7); **7** -15.9 (-8.9); **8** -21.0 (-14.1); **9** -22.7 (-15.9). For *N*-(1-amino-1,2,5,6,7,8-hexahydro-2,5-dioxo-3-quinolinyl)benzamide Hf is -27.1 (-26.3); for 7-methyl derivative -32.2 (-31.5) and for 7,7-dimethyl derivative[2f] -34.0 (-33.2). Values in parenthesis correspond to hypothetical 5-hydrazono isomers. More negative value in a pair corresponds to the more stable isomer.

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